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# Impulsivity Subtypes and Maladaptive Road Performance among Drivers in Germany and Switzerland

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**Abstract:** Excessive speed and speeding substantially compromise road safety in Germany and Switzerland. Approximately one third of all fatal accidents are caused by maladjusted speed. Recent studies attribute a special importance to the impulsivity construct in the context of maladaptive road behavior. Thus, the effects of impulsivity on risky driving behaviors (speeding violations) were examined in a Swiss-German sample of  $N = 361$  car drivers (both on speed affine drivers and putative ordinary drivers). The participants filled in a questionnaire battery consisting of an impulsiveness scale as well as traffic-related attitudes and cognitive appraisal tendencies on the one hand and indicators for maladaptive behaviors at and beyond traffic domain on the other hand. The directions of the observed correlations between the scales were as expected, with impulsivity correlating negatively with age (young drivers scored higher) but not at all with gender or driving experience. To find out more about the functionality of impulsivity, specific personality profiles were carried out via cluster analysis. Three different control types were empirically found (impulsivity subtype, reduced compliance subtype, vulnerability subtype), while high impulsive drivers scored high in impulsivity, low on compliance, high on affective responsiveness and described themselves as affordance-prone. The impulsive type additionally shows more speeding offences stored in the driving license file, overrides speed limits for more than 15 km/h more frequently and even shows deviancy beyond traffic domain. The results are discussed in the light of the impulse control system and conclusions are drawn regarding assessment of driving aptitude and interventions. The theoretical framework including a hierarchical structured model of deviance was confirmed empirically.

**Key words:** Impulsivity, delinquency, speeding, offences, hierarchical deviancy model.

## 1 Introduction

Excessive speed and speeding substantially compromise road safety in Germany and Switzerland. Survey studies found that 20-80% of car drivers do not keep the speed limits [1], depending on road function [2]. Indeed, most of those infringements remain undetected, but this dark figure is also reflected in official offender statistics, e.g. in Germany with 4,799,000 speeding violations, indicating that 55.8% of round about 8.5 million entries in the Central German Register of Traffic Offenders on January 1st 2016 fill that category of risky behavior. Furthermore, speeding

and driving too fast can be seen as the leading factors to crashes and unsafe road traffic as about 30% of fatal accidents are caused by unadapted speed both in Germany, in Switzerland, other EU states, Australia and the USA [3-6].

Previous research has highlighted that speed-affine maladaptive behavior is triggered by affective components (Type A behavioral pattern, sensation seeking, aggression, emotionality), appraisal tendencies within information processing (attitudes, control beliefs, perceived driving competence, risk perception, perceived invulnerability) and presumably insufficient inhibitory mechanisms (e.g., Refs. [3, 6-14]); for cultural differences: Ref. [15]; for the offence fostering moderator accessibility in the context of attitude-to-speeding-behavior, e.g., Refs [16, 17];

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see also Ref. [18]. The concept of dysfunctional impulsivity [19] describes this imbalance between affective risk accelerators and control mechanisms. Accordingly, the impulsivity term seems to shed light on the context of speeding offences and control deficits of maladaptive drivers [20]. Impulsivity is defined as a predisposition to react rapidly and unplanned to internal or external stimuli by ignoring negative consequences at the same time (International Society for Research of Impulsivity).

While traditionally research investigated speeding behavior as a dependent variable, recent studies focused on speeding in combination with other road violations and the driver's criminal history. Therefore, driving too fast is seen as a "syndrome" of maladaptive behavioral patterns [6, 21]. Findings based on relapse rates [21-24] and dissocial behavioral patterns, where traffic offences go hand in hand with a criminal history (compare Refs. [22, 25]; for an overview see Refs. [6, 26, 27]), underpin this conclusion. Consequently, the aim of the present study was to investigate the impact of different impulsivity subtypes, measured by psychological scales, on maladaptive road performance, especially speeding, and violations beyond the traffic domain.

## **2. Conceptual Model**

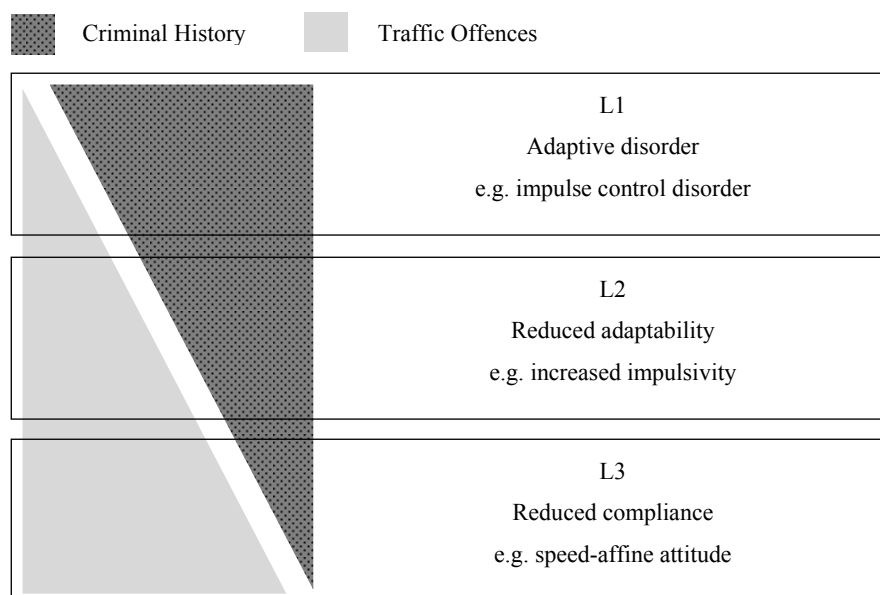
### *2.1 Components of Impulsivity in a Hierarchic Model of Deviance*

Research dealing with specific subtypes on the basis of profiled characteristics to identify high-risk drivers is rare [28, 29]. In order to bridge this gap, we developed a theoretical model of maladaptive traffic behavior (hierarchical deviancy model, HDM) illustrating the interdependence between offence features and a person's maladaptive regulatory structures [30, 31]. HDM describes different levels of deviancy depending on type, severity and heterogeneity of symptoms along with combined cognitive, emotional and dissocial features. Each level represents a problem characteristic with increasingly

inefficient and escalating dysfunctional performance and reduced self-control abilities. Currently, the model postulates different typologies linked to risky road performance (compare Refs. [28, 32, 33]) while attitudes and appraisals are combined in a way to avoid unpleasant feelings, e.g. dissonance [34]. Impulsivity plays an important role in the concept of HDM. Impulsive people show deficits when monitoring their motoric actions without the presence of compulsive behavior or a reduced sagacity (see Refs. [35-38]). Despite of perceived negative consequences they often attract negative attention through inappropriate and self-injurious behavior especially in traffic situations. Previous studies found significant correlations between impulsivity and various behavioral problems (drunk driving, not wearing of seatbelts), substance abuse (alcohol and drugs) as well as delinquency and violent offences (see for example, Refs. [6, 37, 39]). Vice versa: If impulse control was enhanced, researchers observed a gain in traffic safety [18, 40]. Fig. 1 illustrates the hierarchical deviance model (HDM).

To ease comprehension, we introduce the model upwards, starting from level 3 (L3) called "reduced compliance subtype". It describes car drivers with deviant behavior only at the traffic domain. They are socially well integrated and psychologically unremarkable. Speeding offences would be an expression of an area-specific increased risk disposition (e.g., reduced hazard perception) and perceived driving competence. The car driver shows reduced compliance with unremarkable impulsivity. We assume that most of the traffic offenders stored in official files belong to this group.

Level two (L2, called "reduced adaptability subtype") is concerned with a group of people that show predominantly traffic offences but are also prone to committing criminal acts. However, it describes behavior that inadequately uses participation at traffic to regulate emotional states. Those people drive as they live and thus traffic behavior is a reflection of a person's behavioral habits along with deficits in



**Fig. 1 Hierarchical deviance model (HDM).**

emotional control and adaptability. Generalized behavioral patterns are strongly habitualized and therefore reducing the ability to perform the driving tasks adequately. Moreover, those people do not really learn from mistakes. Impulsivity is expected to be at a higher level.

Level one (L1, called “Adaptive disorder subtype”) describes the most severe potential for rule violations namely adaptive disorders and personality disorders. In this category it can be assumed that the abnormalities both in traffic and crime are an expression of a consolidated aberration in the person’s emotional and social development. As a rule, this quality of problem characteristic needs extended psychological treatment. Usually those disorders promote an abnormal and severe history of repeated offences and criminal acts. In most cases there is an impulse control disorder (see Diagnostic and Statistical Manual of Mental Disorders, DSM-IV-R, APA, 2000), which triggers inflexible dealing with environmental requirements [41].

## 2.2 Aim of the Study

The present study analyzes whether, according to the HDM, different components of impulsivity can be profiled with effects due to maladaptive regulation

mechanisms with regard to reduced self-control, including cognitive, emotional and appraisal factors. Personality profiles will be analyzed in conjunction with the driver’s traffic violations, especially speed-affine driving behavior, and criminal history.

We focused on speeding as a widespread offence domain and its high importance for traffic safety [3, 42]. However, speeding should not be misunderstood in a way that speeders are seen as criminals but we want to highlight the idea that speeding may also be one facet of a generalized maladaptive behavioral pattern.

As we rely on self-reported data and did not have any specific diagnoses with regard to clinical impulse control deficit, we focused on levels 2 and 3 of HDM. Consequently, level-2-subtype is expected to show higher values of impulsivity along with convergent appraisal dimensions and more speeding offences compared to level-3-drivers. Additionally, level-2-subjects should report more offences in general, even beyond traffic domain. These findings might serve as validity clues for the HDM’s core assumptions.

## 3. Research Model and Methods

### 3.1 Participants

Participants ranged in age from 18 to 76 years (Mean (M) = 34.10, Standard Deviation (SD) = 12.66). Of the total N = 361 participants, N = 289 (80%) were German and N = 72 (20%) were Swiss, 79% were male (16% female, 5% preferred not to say). As driving too fast is a wide spread phenomenon that a combined sample was carried out including both registrated speed offenders and non-registrated drivers. By choosing a heterogeneous sample, effect size and variance among the variables analyzed were expected to be higher. Speed affine drivers (SAD, N = 169) were defined by minimum one severe violation of the speed restriction (e.g. 30 km/h over the restriction) and/or additional official recorded offences related to speeding (e.g. running a red light, ignoring the car-to-car minimum distance) according to the driver's license file. To receive a homogenous sample of SAD's we set the following exclusion criteria: more than one DUI offence, mostly rule violations at traffic concerning the possession of a car (e.g. not paying insurance), current participation in an intervention measure or having a driving license ban. During the data collection further exclusion criteria were set: problems with the German language, a lot of missing values (more than two items per scale), and suspicious response pattern (e.g. exclusively total agreement or disagreement).

In contrast to the SAD group a sub-sample with non-registered drivers (NRD, N = 192) were randomly drawn from the population of drivers without any known offences.

All participants filled in a questionnaire battery. For the SADs this took place in advance of a mandatory measure, e.g. training program or traffic psychological short term intervention. The participants were asked to fill in the questions concerning their traffic offence history with the aid of their driver's license file so that they had to copy the detailed features of their offences onto the questionnaire. Each participant was assured that the results of the questionnaire had no influence on the following measure. The completed questionnaire was sealed in an envelope and then put into a mailbox.

Although not further examined the rejection rate was very low.

The data collection of the NRD subgroup was implemented at lectures, information sessions, on the campus and we used business contacts with ordinary car drivers and professional drivers to find subjects joining the study. As the driver's license files of the NRDs were not available we could only collect self-reported data of maladaptive road performance.

### *3.2 Measures*

The participants of both study groups filled in a questionnaire battery including demographical variables and scales that measure impulsivity, cognitive appraisal tendencies, emotional responsiveness and impulsive traffic behavior. Additionally, we collected self-reported offences and further indicators of maladaptive behavior, even beyond traffic domain. The SADs copied this data from their driver's license files and the NRDs reported from memory. The four-point Likert-scales measured degree of agreement to a statement (from "strongly disagree" to "strongly agree"; higher scores indicate a stronger magnitude of the scale with the exception of self-control ambitions at traffic which is composed inverted). Some of the items were presented inversely.

To assess impulsivity, we used the Barret Impulsiveness Scale BIS-11 [43] translated into German by the authors of this paper. The BIS-11 consists of 30 Items (e.g. "I am a self-controlled person", Cronbach's  $\alpha = 0.75$ ; M: 1.98; SD: 0.29).

The scale attribution style for rule violations describes a cross-situational tendency to draw a certain kind of causal conclusion (internal vs. external) to explain why violations occurred (see Locus of Control, e.g., Ref. [32]). It was measured by a six-item scale (Cronbach's  $\alpha = 0.68$ , M: 1.93; SD: 0.51; e.g. "many years of driving without being registered or without an accident is pure luck") [44]. People preferring an external attribution style tend to maintain their current behavior because they do not perceive control over the

situation and therefore they don't believe in their own abilities for initiating change processes successfully. The items are directed to the domain of car driving (see Ref. [30]).

The scale affective responsiveness consists of four items (Cronbach's  $\alpha = 0.80$ , M: 1.84; SD: 0.61, e.g. "If I am annoyed it sometimes happens that I compel other drivers to give up priority at traffic"). It describes a tendency to link negative emotional tension into spontaneous misbehavior. Scoring high indicates a reduced action control at negative emotional states (see Refs. [31, 37]).

The scale compliance measures a general tendency to stick to the rules and therefore reflects a security-minded style of driving (five items, Cronbach's  $\alpha = 0.59$ ; M: 3.06; SD: 0.51, e.g. "I deliberately drive more considerate than other drivers that I know"). It contains traffic related aspects of conscientiousness indicating the driver's belief on how to adequately deal with obligations and rules (see Refs. [7, 45]).

To assess the efficacy of self-control ambitions at traffic we used a five-item scale (Cronbach's  $\alpha = 0.83$ ; X: 2.04; SD: 0.59, e.g. "It is sometimes difficult to consequently stick to the restriction on overtaking"). It measures the driver's extent and need of perceived action control (see Refs. [11, 31]). Higher scores indicate a lower ambition to control.

Vulnerability to impulsive actions (six items, Cronbach's  $\alpha = 0.69$ ; M: 2.07; SD: 0.52, "If I have a clear view on rural roads, I drive faster than it is allowed") describes the degree of being affected by the motivational potential of a traffic situation and its affordances [11, 46-48].

Additional biographic features were collected at the beginning of the survey: age, gender, driving experience. Furthermore, indicators of behavioral delinquency and self-reported incidents were recorded: Number of accidents, number of registered speeding offences, maximum speed over the limit, frequency of overriding speed limit for more than 15 km/h (within

the last 1,000 km travelled), additional traffic history (e.g., passing red traffic lights), and deviancy beyond traffic (criminal history including aggressive behavior). Banse et al. [7] found that self reports represent sufficient indicators for risky on-road-performance, as correlations between the number of penalty points stored in the official register and self-reported penalty points are high ( $r = 0.68$ ,  $p < 0.01$ ) as well as the correlation between the official number of speeding offences and the subjective report about that issue are even significant, too ( $r = 0.24$ ,  $p < 0.05$ ). This leads to the conclusion, that self reported data are sensitive indicators for risky driving.

Social desirability was included into the study as a control variable to assess a response bias [49]. This scale expresses the tendency to sugarcoat stated outcomes or to ideally present oneself. It consists of twelve items taken from the Swiss test battery to assess traffic relevant personality traits (called "Testverfahren zur Erfassung verkehrspsychologisch relevanter Persönlichkeitsmerkmale", TVP, Spicher and Hänsen, 2000, Cronbach's  $\alpha = 0.74$ ; X: 2.56; SD: 0.43, e.g. "My behavior has always been flawless").

### 3.3 Methodical Procedure

All scales were composed using best practice experience or indicators taken from the German toolbox for the assessment of driving aptitude [31], as far as we could not use published scales.

The major period of the data collection lasted from May 2013 to June 2014. In Germany and German-speaking Switzerland driving schools, traffic psychologists, seminar facilitators and experts were involved in the systematic data collection for SADs. The combined sample from German and Swiss drivers allowed us to generate a risk continuum of speeding offences ranging from one to fourteen offences.

Statistical analyses were performed using IBM SPSS (Version 20). Missing items values were replaced by scale means if there were not more than two item values per scale missing.

Our analysis followed a stepwise schedule:

(1) In a first step bivariate correlations were computed to measure the relations among the variables used in the study. The correlation analysis was done entirely descriptive to survey the covariates with impulsivity and to replicate existing findings. It is initial for deriving impulsive subtypes via cluster analysis which is the most important issue of this paper.

(2) Cluster analysis involving all personality scales (impulsivity, attribution type of rule violations, affective responsiveness, compliance, self-control ambitions at traffic, vulnerability to impulsive actions, social desirability) was then applied to categorize risky profiles. This was done for the purpose of testing the HDM in order to look for similar subtypes according to deviance levels L2 and L3. In general, a cluster analysis combines subjects via their similarity in certain variables. Using Ward's method, a hierarchical cluster analysis was performed and a structogram was used to determine the number of clusters. The stability of cluster solution was tested by using ANOVAs.

(3) To find out, if the assumptions of the HDM in Fig. 1 are supported by empirical evidence, it is important to take a closer look at the "functionality" of impulsive subtypes and their impact on maladaptive road performance. As mentioned in Fig. 1 the level L2 (reduced adaptability) is characterized by increased impulsivity along with both traffic offences and elements of a criminal history (compare the grey and black triangles in Fig. 1). For testing this assumption, the cluster type was used as an independent variable to compare several indicators of maladaptive road performance: Number of accidents, number of registered speeding offences, maximum speed over the limit, frequency of overriding speed limit for more than 15 km/h, additional traffic history, and deviancy beyond traffic.

Additionally, ANOVAs were computed to test significant differences between the groups.

The level of significance testing was set at 0.05. As

measures of effect size, we computed the eta coefficient as given by SPSS-software in addition to the analysis of variance, respectively.

## 4. Results

### 4.1 Correlation Analysis

Table 1 shows pairwise computed Pearson correlation coefficients among all variables used in the study, including the personality scales, socio-demographic variables and indicators of delinquency. The internal consistency (Cronbach's  $\alpha$ ) of personality scales ranges from 0.59 to 0.83.

The directions of the observed correlations are as expected. For example, higher impulsivity is associated with an external attribution type ( $r = 0.36, p < 0.01$ ), increased vulnerability for impulsive actions ( $r = 0.40, p < 0.01$ ), reduced control ambitions ( $r = 0.43, p < 0.01$ ), higher affective responsiveness ( $r = 0.54, p < 0.01$ ) and lower compliance ( $r = -0.41, p < 0.01$ ). That means that impulsive drivers attribute their rule violations to external factors, they have both a lower self-control and high affective responsiveness. Simultaneously there is a negative correlation to compliance indicating that highly impulsive drivers show only a small tendency to stick to the rules.

Additionally, there were mostly significant correlations among the personality scales in many cases around  $r = 0.50$ . So it makes sense to bundle personality facets to similar clusters for the purpose of mapping different control levels as HDM implies. However, social desirability correlates mostly negatively with the personality variables (for instance impulsivity, affective responsiveness) and positive with compliance. That indicates that the subjects show some bias towards "faking good".

Regarding the measures of delinquency, there are strong correlations between the frequency of overriding speed limit for more than 15 km/h (within the last 1,000 km travelled) with personality scales (positive between  $r = 0.19$  and  $r = 0.50, p < 0.01$ ; negative with  $r = -0.50$  for compliance,  $p < 0.01$ ).

**Table 1 Correlations among all study variables across the entire sample (n = 361).**

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Study variables															
1. Age	-0.03	0.34**	-0.09	-0.07	0.03	-0.15**	-0.04	-0.22**	0.04	-0.10	0.22**	-0.08	0.03	-0.01	-0.05
2. Gender <sup>1</sup>		-0.19**	-0.11	-0.08	-0.08	0.00	0.03	0.05	-0.04	-0.03	-0.19**	-0.11	-0.17**	-0.09	-0.05
3. Driving experience			0.09	0.05	0.14*	0.00	-0.07	0.01	0.05	0.08	0.24**	0.01	0.06	0.11	-0.05
Personality scales															
4. Attribution type of rule violation				0.49**	0.50**	0.48**	-0.41**	0.36**	-0.20**	0.02	0.07	-0.03	0.28**	0.02	0.09
5. Vulnerability to impulsive actions					0.66**	0.53**	-0.63**	0.40**	-0.34**	0.01	0.08	-0.03	0.44**	0.03	0.12*
6. Self-control ambitions at traffic <sup>2</sup>						0.52**	-0.65**	0.43**	-0.40**	0.05	0.24**	0.16*	0.50**	0.10	0.13*
7. Affective responsiveness							-0.53**	0.54**	-0.43**	0.00	0.04	0.04	0.30**	-0.01	0.19**
8. Compliance								-0.41**	0.31**	0.06	-0.24**	-0.12	-0.50**	0.01	-0.12*
9. Impulsivity									-0.37**	0.07	0.18**	0.11	0.19**	0.01	0.16**
10. Social desirability										0.02	-0.04	0.04	-0.20**	-0.01	-0.04
Behavioral indicators of delinquency															
11. Number of accidents (last 5 years)											0.17**	0.04	0.03	0.09	0.18**
12. Number of registered speeding offences												0.26**	0.31**	0.14*	0.04
13. Maximum speed over the limit													0.06	0.18**	-0.04
14. Frequency of overriding speed limit														0.09	0.04
15. Additional traffic history															0.08
16. Deviancy beyond traffic															

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , <sup>1</sup>0 = male, 1 = female, <sup>2</sup> higher scores indicate a lower ambition to control.



Furthermore, there is a significant correlation with social desirability ( $r = -0.20, p < 0.01$ ).

#### 4.2 Cluster Analysis

Following the implications of HDM, we wanted to find out if different impulsivity subtypes can be separated from each other. Accordingly, we used cluster analysis expecting to find profiles representing levels two and three in the HDM [note: Levelone (L1) was not in the focus of this paper].

We found a solution with three clusters: Cluster-1 representing a subgroup resembling subjects of level two (L2) according to HDM, Cluster-2 representing a subgroup resembling subjects of level three according to our model (L3) and a third cluster representing a vulnerability group which is not mentioned in HDM. Fig. 2 shows the z-scores (means of the scales) of the three cluster groups across all scales. Thus, the hypothesized cluster profile could be confirmed. Table 2 displays differences between personality scales across the clusters while F-scores range from  $F = 69.92$  to  $201.68$  (all  $p < 0.01$ ).

We labeled Cluster-1 (or subgroup L2 called “reduced adaptability subtype” according to HDM) as a group comprising subjects from the “impulsive subtype”. This subgroup is characterized by a high degree of impulsivity, low compliance, an external attribution style, increased vulnerability to impulsive actions, low control ambitions, and increased affective responsiveness. Cluster-2 obtained subjects indicating a reduced motivation to comply with the traffic rules (in HDM L3, “reduced compliance subtype”). The graph shows a curve line profiling a parallel trend of reduced magnitude across the personality scales compared to cluster 1 (Fig. 2).

A third cluster called “vulnerability subtype” is characterized by a high degree of compliance, low scores on attribution type (indicating an internal

attribution style where errors and rule violations are located to the driver himself and not to traffic situation or other drivers), a low tendency for impulsive actions, high control ambitions, low affective responsiveness and high levels of social desirability. This subtype also shows a low level of impulsivity and the members of that group turn out to be self-controlled. This specific profile might be evidential for a vulnerability tendency that differs from other subtypes.

#### 4.3 Impulsivity Subtypes and Maladaptive Road Performance

As our attempt was to highlight the functionality of personal profiles as “triggering factors” for rule violations and maladaptive behavior we analyzed mean differences between behavioral indicators of delinquency. For testing this approach, the cluster type was used as an independent variable and differences between the subtypes were analyzed by ANOVA’s across the self-reported behavioral indicators of delinquency.

Table 3 represents the results. Conducted ANOVAs indicated significant between-group differences for number of registered speeding offences ( $F_{2,347} = 7.08, p < 0.01$ ), frequency of overriding speed limit in general ( $F_{2,357} = 30.28, p < 0.01$ ) and deviancy beyond traffic ( $F_{2,351} = 5.51, p < 0.01$ ). Follow-up comparisons (Tuckey’s HSD) show that impulsivity subtype subjects report more registered speeding offences (compared to vulnerability subtype), more frequently overriding speed limit in general (significant mean differences to reduced compliance subtype and vulnerability subtype) and declare more deviancy events beyond traffic (compared to the two other groups). No differences were found for the number of accidents, maximum speed over the limit and additional traffic history.

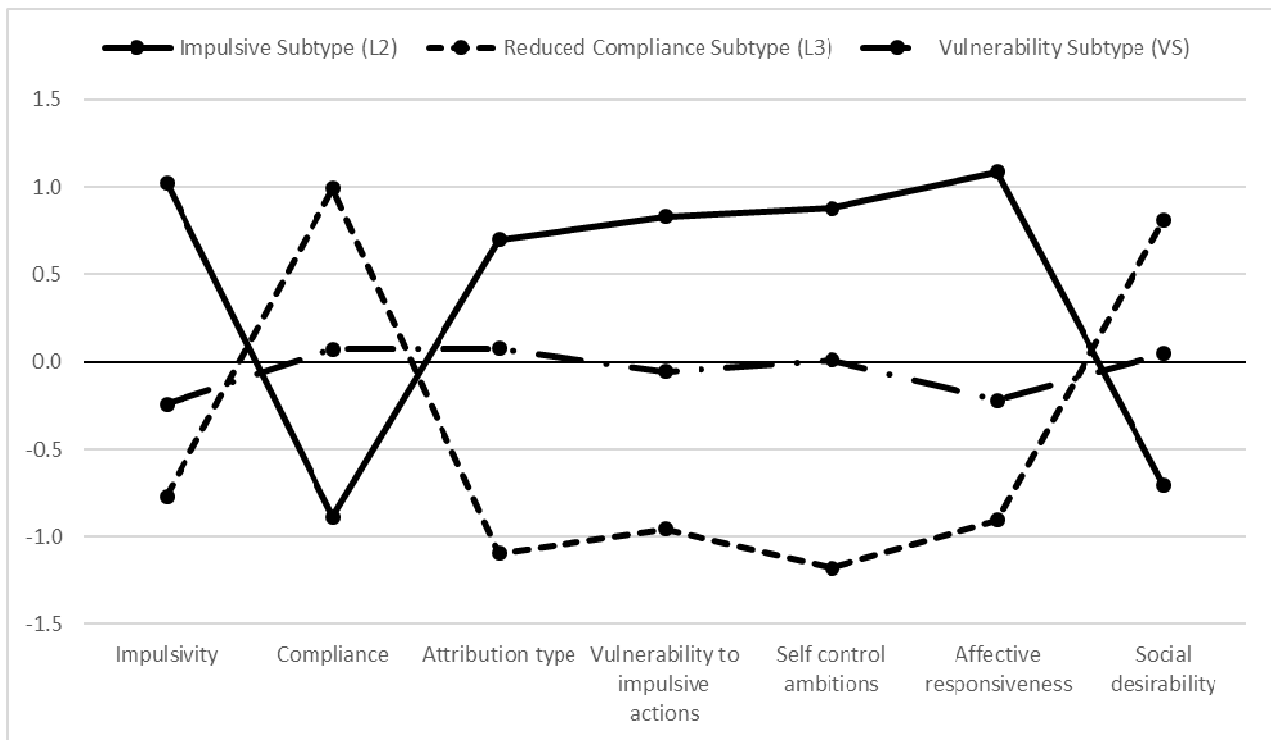


Fig. 2 Type profiles. All variables were z-standardized.

Table 2 Differences between impulsivity subtypes (ANOVAs).

	Impulsive subtype (L2)	Reduced compliance subtype (L3)	Vulnerability subtype (VS)	F	df	eta <sup>2</sup>
Impulsivity	2.28 (0.26)	1.98 (0.29)	1.76 (0.20)	147.69**	2,358	0.45
Compliance	2.61 (0.41)	3.10 (0.41)	3.57 (0.29)	137.00**	2,358	0.43
Attribution type	2.29 (0.41)	1.97 (0.44)	1.37 (0.26)	117.96**	2,358	0.40
Vulnerability to impulsive actions	2.51 (0.37)	2.05 (0.44)	1.58 (0.36)	114.78**	2,358	0.39
Self-control ambitions	2.56 (0.44)	2.05 (0.44)	1.35 (0.29)	189.46**	2,358	0.51
Affective responsiveness	2.51 (0.46)	1.71 (0.43)	1.29 (0.34)	201.68**	2,358	0.53
Social desirability	2.26 (0.37)	2.58 (0.37)	2.91 (0.34)	69.62**	2,358	0.28

Table 3 Differences between impulsivity subtypes in maladaptive road performance indicators and deviancy beyond traffic.

	Impulsive subtype (L2)	Reduced compliance subtype (L3)	Vulnerability subtype (VS)	Total	F	df	eta <sup>2</sup>
Number of accidents (SD)	0.56 (0.84)	0.43 (0.75)	0.52 (0.93)	0.48 (0.82)	1.02	2,358	0.01
Number of registered speeding offences (SD)	2.81 (2.80)a	2.23 (2.19)a	1.47 (1.78)b	2.23 (2.34)	7.08**	2,347	0.04
Maximum speed over the limit in km/h (SD)	32.78 (21.13)	29.02 (17.06)	30.45 (15.98)	30.34 (18.10)	1.02	2,255	0.01
Frequency of overriding speed limit in general <sup>1</sup> (SD)	3.82 (1.70)a	3.13 (1.48)c	2.11 (0.95)b	3.11 (1.57)	30.28**	2,357	0.15
Additional traffic history (SD)	0.43 (1.01)	0.67 (2.53)	0.22 (0.61)	0.51 (1.91)	1.53	2,344	0.01
Deviancy beyond traffic (SD)	0.27 (0.90)a	0.06 (0.39)b	0.04 (0.26)b	0.11 (0.57)	5.51**	2,351	0.03

Note: \*\*  $p < 0.01$ ; Different letters (a, b, c) indicate statistically significant mean differences between the clusters at the 5% level (Tuckey's HSD);

<sup>1</sup>more than 15 km/h above limit during the last 1000 km of driving 1 = never, 2 = up to 5%, 3 = up to 10%, 4 = up to 20%, 5 = up to 40%, 6 = up to 50%, 7 = more than 50% of the time.

## 5. Discussion and Conclusions

The aim of this study was to validate the hierarchical structure of HDM through empirical findings. This model of maladaptive traffic behavior has been designed in the context of the assumption that different control levels might be contrasted against each other. Here, impulsivity components are mapped together with attitudes and appraisal tendencies. However, although this model seems to be rationale on theoretical grounds empirical data based on reasonable large samples are still missing. Using a relatively large German and Swiss sample we were able to objectively identify three subgroups on the basis of traffic-related self-reports.

The first group we identified on the basis of the cluster analysis (labeled “reduced adaptability subtype”) represents subjects that strongly compromise traffic safety (see also Ref. [28] or Ref. [29]). Risky behavioral patterns are the result of the interaction between less well-regulated affect, high impulsivity and low legitimate attitudes as well as appraisal tendencies. This pattern indicates a weak top-down control through the dorsolateral prefrontal cortex, which controls and inhibits arising emotional impulses (compare Ref. [50]). The balance between top-down control and bottom-up regulation is seen as an important neurophysiological prerequisite for impulse control (compare Ref. [51]). Dysfunctional regulation of these bottom-up and top-down processes impairs self-control mechanisms and most likely enhances also abnormalities in other life domains [37, 52, 53].

The second group we identified is a subtype marked by reduced motivation in keeping the rules (“reduced compliance subtype”). This subtype shows medium levels of impulsivity and also demonstrates less extreme scores in further personality variables, in the amount of speeding incidents, further offenses in traffic and a high number of unknown offenses. However, the tendency for delinquency is mostly restricted to traffic situations.

The third subtype (“vulnerability subtype”) shows low impulsivity, which indicates a more elaborated self-regulation and further features that are positive for traffic safety: high compliance, an internal attribution type, a low tendency for spontaneous impulsive actions, high situational control ambitions and low affective responsiveness. This profile is strongly influenced by a high level of social desirability indicating the tendency to accommodate oneself to social situations by choosing a moral bias for the purpose of masking unsafe cognitions. In short: Those persons are able to optimally use their social skills to present themselves in a positive light as a “successful self-regulator” [54]. Following Rößger et al. [11], one can assume that this group is sensitive in certain situations: they exactly can “read” a traffic situation and they act like “rational egoists” and perceive violating behavior to be under their control.

### 5.1 Implications for the Future

In our view these findings should stimulate further intensive research using other variables than in our study. Here we have worked basically with self-report data, which only reflect the First-Person-Perspective (1PP) of human behavior. It would also be helpful to obtain objectively measured behavioral, and physiological as well as neurophysiological data of self-control and impulsivity representing the Third-Person-Perspective (3PP). Only when combining both perspective levels in a “complementary way” one will understand human behavior and traffic-related behavior in particular more precisely.

Nevertheless, regarding the proposed hierarchic model of deviance and our analysis, impulsivity seems to be pivotal in maladaptive coping processes while interacting with situational demands. Following Berdoulat et al. [55] and Jaencke [18] impulsivity is a valid predictor of different severity levels of offenses in traffic situations. In this context it should be emphasized that “sensation seeking” (a construct

which is strongly related to impulse control) predicts the frequency of self-directed harmful events while non-planning (another facet of impulsivity) is associated with intensity of adaptive disorder characteristic [37]. It currently remains unclear why some subjects demonstrate higher impulsivity levels or less top-down control than others. Several possibilities are currently discussed which need further examination in particular when one tries to understand impulsivity in traffic situations. It might be that some subjects are genetically equipped with less strong top-down control mechanisms. These subjects would suffer from impulse control problems throughout their entire life not only in traffic situations but also in other domains of every-day life. In fact, there are several papers published so far supporting this idea of a kind of innate weak top-down control system affecting self-control and impulsivity throughout the life [56]. A further possibility could be that subjects with a kind of vulnerability of this top-down system are raised in a detrimental social environment in which they do not practice self-control that much at the end enhancing the control deficit. However, although rational these ideas at least should be tested explicitly. For this longitudinal studies would be the optimal experiments strategies addressing the development of the behavioral patterns described in the hierarchic model. In this context it is conceivable that the development of maladaptive regulation structures may be triggered by curiosity and sensation seeking while positive experiences reinforce the person's preferences to choose attractive situations or action patterns. It is obvious that there are strong parallels between the theoretical concept of the development of maladaptive behavior in traffic and the development of an addictive disorder. Both share the idea that curiosity and sensation seeking are the motivation to start a specific behavior, followed by positive effects. The wish for repeated positive stimulation and emotion modulation subsequently increases the incidence of the harmful behavior despite the experience of negative consequences. This is

followed by limitations in the behavioral control and the problem area spreads out to other life domains. These noticeable parallels should be further examined in the light of an integrated theoretical approach.

A further implication of this study should emphasize and stimulate further research on rehabilitation of impulse control problems. From the different risk profiles, we have identified so far one can derive different rehabilitation approaches based on the different necessities for fundamental changes in the client's cognition and behavior [28, 30]. Therefore, a diagnosis should clarify the level of severity. For that a combination of objective file analysis and personality diagnosis would be preferable (see Ref. [31]). It is known that interventions focusing on improvement of self-reflection, awareness of the problem characteristic and risk perception are associated with lower relapse rates at traffic (see Refs. [30, 57, 58]). However, other kinds of rehabilitation and training regimes are also conceivable which target more strongly on the neurophysiological control mechanisms (e.g., transcranial magnetic stimulation: TMS; transcranial direct current stimulation: TDCS; neurofeedback techniques). For a reduced ability to cope (level L2, or "increased impulsivity" group) additional work on emotion control, attention control and increased perceived self-efficacy combined with a shift in the attribution tendency would be advisable [28]. Overall the aim would be to correct the reduced adaptability in terms of the hierarchic model of deviance.

A third consequence of this research could be to change traffic-related enforcements embedded in a strict traffic regulation system. For example, speeding is a widely spread problem. Also in the present study one in five participants acknowledged driving 15 km/h faster than the speed limit within the last 1,000 km travelled. Greaves and Ellison [42] found that the speed limit is exceeded in 19% of the distance traveled by car. According to Rößger et al. [11], an increase of speeding controls (like in France and Switzerland) but also section-control methods are advisable along with

administrative measures operated by the driving license authorities. Here, stepwise implemented voluntary and mandatory interventions should be combined in a penalty point system. In order to buffer unwanted offense biographies the starting point might be after two high-range offenses.

### 5.2 Limitations

There are a couple of limitations in the present study that have to be discussed. Firstly: the sample composition. Non-impulsive profiles in the Swiss subsample could be due to a systematic effect bridged by the context of assessment setting. Maybe younger persons in such assessments might show a different response pattern than persons waiting for a special preventive program. Secondly: Recent approaches to assess impulsivity combine different aspects of impulsivity [38] so that the use of only one questionnaire might lead to an underestimation. Combining the so called “UPPS-P”-facets referring to negative urgency, (non-)planning, perseverance, sensation seeking, and positive urgency [37] towards an integrated behavioral measure consisting of reaction time and mistakes (representing the aspect urgency which is the tendency to rashly act) along with appraisals and behavioral items might be promising elements enhancing its content validity. Thirdly the observed frequency of delinquency beyond traffic was relatively low and the complete hierarchic model of deviancy could not be tested. Furthermore, actual behavioral data would be desirable [42]. Fourthly: The NRD group reported memorized offenses, which could not be validated by a view in the driving license file. Intentional biases or recall effects cannot be excluded. Finally: In this paper we entirely rely on subjective self-report measures (1PP). However, it is necessary to extend this research by also using objective 3PP measures to paint a more complete picture of the underlying mechanisms of inappropriate driving behavior.

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